Tuesday, June 26, 1990

Proposal to Use the NWA Electron Test Beam at Fermilab for Tests of a Lead Glass Calorimeter Prototype

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Abstract

This is a request from part of the Brookhaven E852 collaboration to use the NW electron test beam, at Fermilab, for tests of a 25-element, lead glass detector (LGD) prototype. This LGD prototype will be fully instrumented and is a fore-runner of a 3000-element LGD to be used in the BNL MPS for E852: *A Search for Mesons with Unusual Quantum Numbers*. We propose to run the electron beam at 20 GeV and will need approximately 100 hours of beam time.

Spokesman: S. Teige

Introduction

Brookhaven Experiment 852: *A Search for Mesons with Unusual Quantum Numbers* was recently given approval[1] for 2400 hours of running at Brookhaven National Lab starting in early 1993. This experiment will search for exotic mesons, hybrid mesons and glueballs by searching for decays modes with multi-photons and 0,1 or 2 charged particles. Examples of reactions which will be studied with an incident 21 GeV/c π^- beam will be:

$$\pi^-p \rightarrow M^\circ n \rightarrow \eta\pi^\circ n \rightarrow 4\gamma n \qquad (1)$$

$$\pi^-p \rightarrow M^-p \rightarrow \eta\pi^-p \rightarrow 2\gamma\pi^-p \qquad (2)$$

$$\pi^-p \rightarrow M^\circ n \rightarrow \eta\eta n \rightarrow 4\gamma n \qquad (3)$$

Reaction (1) is of interest because if the $\eta\pi^\circ$ system resonates in a P-wave then $J^{PC} = 1^{-+}$ which cannot be formed from a quark-antiquark system. In fact the GAMS group has reported an exotic $J^{PC} = 1^{-+}$ with a mass of 1405 MeV at Serpukhov[2] (incident 38 GeV/c) and CERN[3] (incident 100 GeV/c) in reaction (1). Since I =1 for $\eta\pi^\circ$ then a resonance which appears in reaction (1) should also appear in reaction (2). Another interesting reaction is (3). The scalar G(1590) has been reported[4] in the $\eta\eta$ system with unusual decay modes:

$\pi^\circ\pi^\circ$	$K\bar{K}$	$\eta\eta$	$\eta\eta'$	$4\pi^\circ$	occur in the ratio	0.3	≤ 0.6	1	2.7	0.8

E852 will be sensitive to all these decays modes (GAMS and other experiments are not). Finally the $\eta\eta$ system also allows a study of the $\theta(1700) \rightarrow \eta\eta$ in hadroproduction. The θ is seen in the glue–rich J/ψ radiative decays and is therefore a glueball candidate.

E852 will use the BNL MPS augmented with a 3000-element LGD, a CsI(Tl) barrel surrounding the target to veto on soft-photons from Δ° and $N^{*\circ}$ decays, tracking chambers and a segmented Cerenkov counter. The apparatus is shown in Fig. 1. The complete list of E852 collaborators is shown in Table I.

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[1] AGS Proposal P852 submitted to the AGS APC in November, 1989 by the E852 Collaboraation: Brookhaven, Indiana U., U. of Louisville, Southeastern Massachusetts U., Moscow State U., U. of Notre Dame and U. of Washington. The Co-Spokemen are: S. U. Chung (BNL) and A. R. Dzierba (IU).

[2] M. Boutemeur *et al.*, Proceedings of the BNL Workshop on Glueballs, Hybrids and Exotic Hadorns, American Institute of Physics Conference Proceedings No. 185 (1989) 389.

[3] D. Alde *et al.*, Phys. Lett. **205B** (1988) 397.

[4] F. Binon *et al.*, Nuov. Cim. **A78** (1983) 313; F. Binon *et al.*, Nuov. Cim. **A80** (1984) 715;F. Binon *et al.*, Phys. Lett. **182B** (1983) 313.

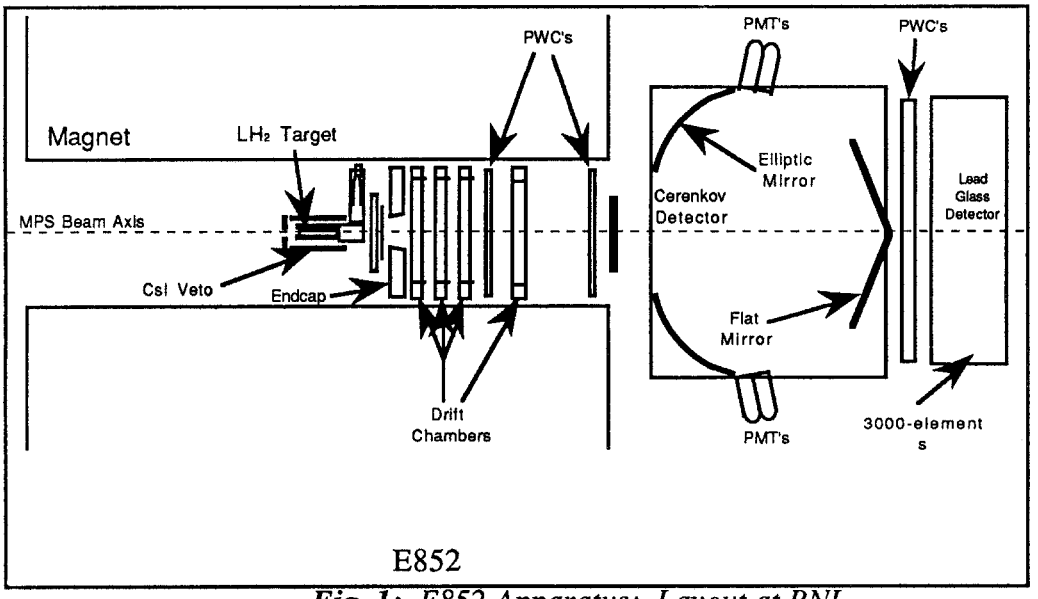

Fig. 1: *E852 Apparatus: Layout at BNL*

The AGS APC gave a strong endorsement of E852. Quoting from the approval letter: "The Program Committee reiterated its enthusiam for the physics goals of this experiment which complement programs at other laboratories and offer the possibility of fundamental discoveries. This experiment, and its associated upgrades and additions to the MPS, are regarded by the Committee as the beginning of a lively, long-term program in precise meson spectroscopy at BNL".

Photon Energies

The specrum of photons expected in reaction (1) from the decay of a peripherally–produced M° with a mass of 1405 MeV is shown in Fig. 2.

The maximum photon energy is 20 GeV and the mean is about 5 GeV.

Prototype LGD Tests at Fermilab

The heart of the E852 detector is a 3000-element lead-glass detector. Each element is F2 lead glass, 4 cm x 4 cm in transverse dimensions and 45 cm long. We are considering using radiation-hard F101 glass for the modules near the beam line. Each element will be read out using a Russian FEU-84-3 photomultiplier tube. We are constructing a 25-element square array for use in test beams at FNAL and Brookhaven. The array will use F2 glass. We will also provide for re-stacking the array and replacing 4 of the F2 modules with F101 glass.

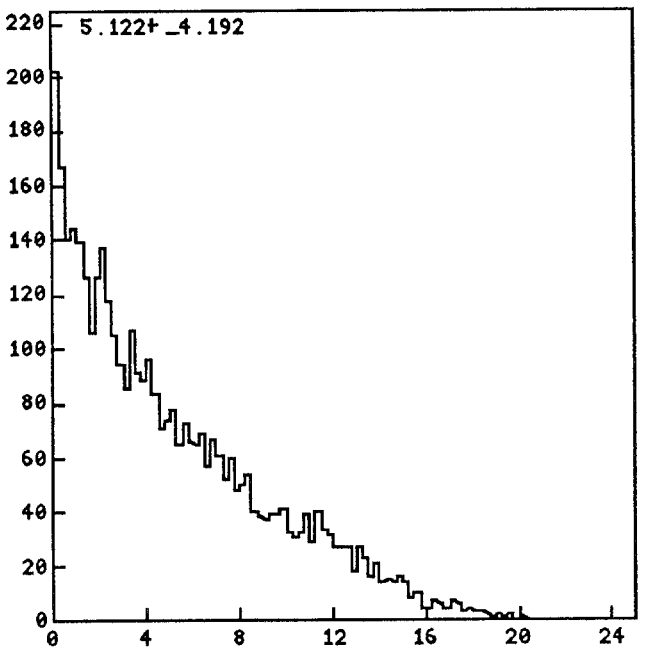

Fig. 2: *Energy of any γ from reaction (1) (GeV)*

The prototype LGD will be mounted in a light–tight, temperature–controlled box. The box will sit on a table which can be easily rolled in or out of the beam line. The box on the table can be translated horizontally or vertically over a 20 cm range in both directions. The box can also be rotated about a vertical axis and locked into one of 5 positions.

The LGD will be fully instrumented with a VAX II workstation (running *PVWave* as the online software package), a FASTBUS crate and interface, a CAMAC crate and interface, a LeCroy HV system, Phillips 10C2 fast-encoding ADC's, a Xe flash lamp/fiber optic monitoring system and temperature monitors.

We will also provide a counter telescpe to provide a trigger and two drift chambers (each with 3 planes, 500 μ resolution) with FASTBUS TDC readout.

The major purpose of the prototype tests is to check our GEANT simulations of the lead glass response. Several specific questions we are addressing:

- what is the energy resolution and and spatial resolution ?

- how are the energy and spatial resolution affected when crossing a region from F2 glass to radiation-hard glass ?

- how do energy and spatial resolution change as a function of angle of incidence ?

- how does the energy resolution change as we sweep electrons across the boundary between two modules.

Simulation Studies

We have simulated 20 GeV electron showers in our 5 x 5 prototype LGD using GEANT, propagating the Cerenkov photons and folding in the transmission of the glass as a function of wavelength and the quantum efficiency of the phototube. Our studies show that the expected σ_E at 20 GeV is 2.3 %. We have also have studied the dependence of spatial resolution on energy. We find, using energy sharding information, that the shower centroid can be located with $\sigma \approx 2$ mm at 20 GeV. Our GEANT studies are in progress and we expect to have firm predictions for the plannned measurements listed above bySeptember 1, 1990.

Request from Fermilab

Beam

We will use 20 GeV electrons in the NWA beam. We understand that $\Delta p/p < 1$ % , that $\sigma_{VERTICAL} \approx 2$ cm and $\sigma_{HORIZONTAL} \approx 4$ cm and the flux is ≈ 50 to 100 e's/spill. Assuming a repetition period of 68 sec we will get about 4000 electrons/hour. Assuming 10,000 electrons for a precision measurement, we can make 10 precision measurements in a 100-hour run.

Space

We will need approximately 2 m (linear) of space in the beam.

PREP Request

We will need two LeCroy 621 disciminators and a LeCroy 364 coincidence unit to define the trigger.

Other Considerations

We plan to have the full prototype assembled by September 1, 1990. This includes having all online software ready to correlate electron position information with that from the LGD.

Table 1: E852 Personnel

Insitution contact people are underlined. Positions shown in italics are presently planned but unfilled

Institution	Ph. D. Physicists	Engineers and Technicians	Thesis Graduate Students
Brookhaven National Lab	S. Chung, D. Weygand, H. Willutzki	*3 fte techs* *+ 1 engineer*	*+1*
Indiana University	B. Brabson†, R. Crittenden†, A. Dzierba†, S. Teige, D. Zieminska *+ 1 postdoc*	T. Sulanke, P. Smith, *+ 2 techs*	R. Lindenbusch, C. Murphy, T. Foxford
University of Louisville	C. Davis†		*+ 1* §
Southeastern Mass U.	Z. Bar-Yam†, J. Dowd†, W. Kern†, E. King		*+ 1* §
University of Notre Dame	J. Bishop, N. Cason†, J. LoSecco†, R. Ruchti†, W. Shephard† *+ 1 postdoc*	B. Baumbaugh *+ 1 tech*	J. Manak, S. Taegar *+ 1*
University of Washington	T. Burnett† *+ 1 postdoc*	*+ 2 techs*	*+ 2*
Moscow State University	V. Bodyagin, L.Bravina, A. Demianov, A. Gribushin, N. Kruglov, A. Ostrovidov, A. Proskuryakov, L. Sarycheva†, N. Sinyov	*2 techs*	*+ 1*
IHEP Serpukhov	S. Denisov *+ 2 physicists*	*2 techs*	

† Teaching faculty member

§ graduate students will be also be affiliated with a Ph. D.-granting institution within the collaboration